PLATE 2 of 3

Utah Geological Survey Geologic Map 180
Geologic Map of the Moab and eastern part of the San Rafael Desert 30'x60' Quadrangles, Grand and Emery Counties, Utah, and Mesa County, Colorado

UTAH GEOLOGICAL SURVEY
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UTAH DEPARTMENT OF NATURAL RESOURCES
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DESCRIPTION OF GEOLOGIC UNITS

Quaternary Deposits

Qf Artificial fill -- Clay- to boulder-size material in tailings, railroad and road fill, and dams that are large enough to map at the 1:100,000 scale; locally as much as 21 meters (70 ft) thick; late Holocene.

Qal Stream alluvium -- Sand, silt, clay, granules, pebbles, and sparse cobbles adjacent to more active stream courses; unconsolidated, poorly to well-sorted channel-fill and low terrace deposits; thickness varies widely, but commonly less than 10 meters (33 ft) thick; Holocene to late Pleistocene.

Qam Alluvial mud -- Light- to medium-gray silt, clay, sand, and minor fragments of sandstone, mostly derived from members of the Cretaceous Mancos Shale; unconsolidated; fills swales in the softest parts of the Mancos Shale; thickness less than 10 meters (33 ft); Holocene to late Pleistocene.

Qap Pediment-mantle deposits -- Poorly to moderately sorted, rounded to angular boulders, cobbles, pebbles, granules, sand, silt, and clay; cover bedrock surfaces between drainages as much as 120 meters (400 ft) above local base level; commonly less than 30 meters (100 ft) thick; mostly late Pleistocene.

Qaf Alluvial-fan deposits -- Poorly sorted, angular to subrounded gravel, containing cobbles and sparse boulders, in crudely bedded to unstratified granules, sand, silt, and clay matrix; cut-and-fill channel features locally present; deposited at the foot of mountains, cliffs, and at the mouths of streams; thickness commonly less than 15 meters (50 ft); Holocene to late Pleistocene.

Qat Terrace deposits -- Cobbles, granules, pebbles, sand, silt, and clay adjacent to, but higher than, river, stream, and larger ephemeral stream courses; locally as high as 200 meters (650 ft) above present stream courses; generally contain clasts from distant upstream sources (metamorphic, igneous, and chert clasts); thickness mostly 5 meters (16 ft) or less, but may be 20 meters (60 ft) or more in salt valleys; late to middle Pleistocene.

Qag Alluvial gravel, undifferentiated -- Clast sizes vary from deposit to deposit; no particular geomorphic form or location; thickness commonly 5 meters (16 ft) or less.

Qab Basin-fill alluvium -- Sand, silt, clay, granules, pebbles, and cobbles; may contain local lacustrine or eolian deposits; fills depressions created by salt dissolution in Pennsylvanian Paradox Formation; may be as much as 180 meters (600 ft) thick; mostly Pleistocene in age, commonly covered by Holocene unconsolidated deposits.

Qst Tufa deposits -- Mostly drab, light-yellow-gray, calcareous tufa, some yellow ocher to dusky red brown, porous, crudely laminated, locally thin bedded; weathers in plates and platelets; formed by cold-water springs and geysers; thickness as much as 7.5 meters (25 ft); Holocene to middle Pleistocene.

Qea Mixed eolian and alluvial deposits -- Sand and silt of eolian origin interspersed with silt, sand, and gravel of fluvial origin; generally dominated by eolian deposits; commonly displays a well-developed caliche soil horizon at the top; thickness 10 meters (33 ft) or less; Holocene to middle Pleistocene.

Qes, Qed Eolian deposits -- Well-sorted sand and silt; deposited in sheets (Qes) and dunes (Qed); commonly fills hollows in sandstone outcrops or collects on the lee sides of cliffs and slopes; thickness 15 meters (50 ft) or less; mostly Holocene.

Qgt Glacial till -- Very poorly sorted, angular to subangular clasts of all sizes; larger clasts are commonly striated; fills U-shaped canyons in the La Sal Mountains; as much as 90 meters (300 ft) thick in lateral moraines; early Holocene to late Pleistocene.

Qmt Talus and colluvium -- Rock-fall blocks, boulders, smaller angular gravel, sand, and silt; deposited on slopes below cliffs and steep slopes; only larger deposits mapped; thickness generally 4.5 meters (15 ft) or less; Holocene to late Pleistocene.

Qms Slumps and slides -- Coherent to broken and jumbled masses of bedrock that have moved downslope due to gravity; most commonly associated with the Jurassic Brushy Basin Member of the Morrison Formation; varied thicknesses; Holocene to late Pleistocene.

Qcb Bouldery colluvium -- Large angular blocks covering slopes in La Sal Mountains; broken by freeze and thaw of hard rock units; may be as thick as 30 meters (100 ft); Holocene to late Pleistocene.

Q Quaternary deposits, undivided (shown on cross sections only) -- Mostly basin-fill deposits (Qab); Holocene and Pleistocene.

Quaternary-Tertiary Deposits

QTaf Older alluvial-fan deposits -- Sand, silt, granules, pebbles, cobbles, and sparse boulders deposited at the foot of the La Sal Mountains; thickness 60 to 90 meters (200-300 ft); early Pleistocene to Pliocene(?).

Tertiary Rocks

Tg Geyser Creek Fanglomerate -- Yellow-brown, light-brown, and light-gray conglomerate, sandstone, and siltstone derived from the La Sal Mountains; generally poorly sorted and weakly cemented with calcium carbonate; thickness as much as 305 meters (1,000 ft), but exposures are generally less than 92 meters (300 ft) thick; Pliocene(?).

Ti La Sal Mountains intrusive rocks -- Hornblende-plagioclase trachyte, quartz-plagioclase trachyte, peralkaline trachyte, peralkaline rhyolite, and nosean trachyte; all porphyritic with fine-grained to aphanitic ground mass (Ross, unpublished data, see 13 and 14); intruded at shallow depths as laccoliths, plugs, sills, and dikes; includes breccia pipes; emplaced 25 to 28 million years ago (Oligocene).

Cretaceous Rocks

Kf Farrer Formation -- Interbedded light- to dark-brown, medium-grained, thin- to thick-bedded sandstone and pale-gray, green-gray, and brown mudstone and siltstone; ledge and slope former; lower contact gradational, placed above highest carbonaceous beds in the Neslen Formation; only lower part preserved in the quadrangle; 70 to 204 meters (230-670 ft) thick; Campanian.

Kn Neslen Formation -- Interbedded light- to dark-gray mudstone, carbonaceous shale, and coal and light- to dark-brown sandstone; slope-former with sporadic prominent ledges; coal beds generally less than 0.6 meters (2 ft) thick; lower contact at top of Sego Sandstone cliff; about 43 meters (140 ft) thick; Campanian.

Ks Sego Sandstone -- Light-gray and yellow-gray sandstone and gray mudstone; sandstone is fine to medium grained, massive, and cliff-forming; mudstone is slope-forming; displays hummocky bedding, cross-bedding, convolute bedding, ripple laminations, and bioturbation; contains trace fossils; contact with Buck Tongue of Mancos Shale is gradational, placed at the base of the first medium-bedded sandstone bed; about 40 meters (130 ft) thick; Campanian.

Kmv Mesaverde Group (shown on cross sections only) -- Includes Farrer, Neslen, and Sego Formations; does not include lower Mesaverde tongue of Castlegate and Blackhawk Formations.

Kmb Buck Tongue of Mancos Shale -- Medium- to dark-gray marine mudstone or shale; forms badland slopes; contains thin, fine-grained sandstone beds at top; distinct contact with Castlegate Sandstone below; 37 to 73 meters (120-240 ft) thick, thinning westward; Campanian.

Kc Castlegate Sandstone -- Pale yellow-orange and light-gray, cross-bedded sandstone interbedded with minor mudstone, carbonaceous shale, and coal; sandstone is fine grained, generally thick bedded to massive, and cliff and bench forming; locally bioturbated, contains trace fossils; lower contact generally placed above highest carbonaceous shale bed in the Blackhawk Formation; 18 to 30 meters (60-100 ft) thick, thinning eastward; Campanian.

Kb Blackhawk Formation -- Pale yellow-orange to light-brown sandstone interbedded with mudstone, carbonaceous shale, and coal; sandstone is very fine grained, generally thick bedded, and cliff forming; lenticular coal beds less than 30 centimeters (1 ft) thick; locally extensively bioturbated, contains trace fossils, leaf imprints, and rare shark teeth; gradational with the upper (Blue Gate) shale member of the Mancos Shale, contact is placed at the base of the first thick or medium bed of sandstone; 9 to 40 meters (30-130 ft) thick, thinning eastward; Campanian.

Kmu Kms Upper shale (Blue Gate) member of Mancos Shale -- Mostly light- to dark-gray, marine, thinly laminated to thin-bedded, slope-forming shale, mudstone, and siltstone interbedded with subordinate yellow-brown to yellow-gray, mostly very fine- to fine-grained calcareous sandstone that crops out in several thin mappable (Kms) zones of subtle ledges and cliffs; the middle, more sandy part of the upper shale member that contains most of the ledges is the Prairie Canyon Member of Cole and others (1997); zone of thin-bedded, fine-grained sandstone at top; lower contact with Ferron Sandstone Member is gradational; about 1,020 meters (3,350 ft) thick; Campanian to Turonian.

Kmf Ferron Sandstone Member of Mancos Shale -- Brown-gray to yellow-gray, marine, fine-grained sandstone, sandy mudstone, and carbonaceous shale; fissile to thin bedded; generally forms two sandstone cuestas with a slope of dark-gray to black carbonaceous shale between them; locally fossiliferous; lower contact is a subtle scour surface locally overlain by lenticular lag deposits of pebbly, medium- to coarse-grained sandstone; 15 to 40 meters (50-130 ft) thick; Turonian.

Kmt Tununk Shale Member of Mancos Shale -- Light- to dark-gray, marine shale or mudstone; contains fine-grained sandy zones, especially near the top; slope forming; locally contains concretionary Coon Springs Bed in the upper third of the unit; lower contact with Dakota is abrupt but conformable. The lower contact is an unconformity where the Dakota is missing (Western exposures) and marked by change from green (Cedar City Fm.) to gray shale; 45 to 120 meters (145-390 ft) thick, generally thicker to west; Turonian to Cenomanian.

Km Mancos Shale and other formations, undivided-- On cross sections, includes Buck Tongue of Mancos, Castlegate Sandstone, Blackhawk Formation, upper shale (Blue Gate) member, Ferron Sandstone Member, and Tununk Shale Member of Mancos Shale, as well as Dakota Sandstone. On map in Salt Valley area, includes lower part of upper shale, Ferron, and Tununk members.

Kd Dakota Sandstone -- Yellow-gray to brown sandstone, conglomeratic sandstone, and conglomerate interbedded with gray mudstone, carbonaceous shale, coal, and claystone; commonly forms cliffs and ledges; commonly divisible in the east part of the quadrangle into upper and lower cliff-forming sandstone and conglomerate and a middle, slope-forming mudstone unit; scoured into the Cedar Mountain or Burro Canyon Formations; 0 to 37 meters (0-120 ft) thick, discontinuous in west part of quadrangle, thickens eastward; Cenomanian.

Kdcm Dakota Sandstone and Cedar Mountain Formation, undivided -- Mapped in areas where they are too thin or where they are too difficult to separate accurately.

Kdbc Dakota Sandstone and Burro Canyon Formation, undivided -- Mapped in areas where they are too thin or where they are too difficult to separate accurately.

Kcm Cedar Mountain Formation -- Drab olive-green to variegated mudstone and brown to gray sandstone, gritstone, conglomerate, and limestone; mudstone is slope forming, other rock types form ledges; locally contains petrified wood; lower contact (unconformity) is placed at base of a prominent sandstone or conglomerate ledge or cliff above the brighter variegated mudstone of the Brushy Basin Member of the Morrison Formation; correlative with the Burro Canyon Formation; 12 to 76 meters (40-250 ft) thick, thins irregularly eastward; Albian.

Kbc Burro Canyon Formation -- Brown to gray sandstone, gritstone, conglomerate, and limestone and olive-green to gray mudstone; mostly cliff forming; correlative with Cedar Mountain Formation; exposed southeast of the Colorado and Dolores Rivers; lower contact (unconformity) is abrupt and placed at base of a conglomeratic sandstone above underlying, undivided -- North of Tenmile graben and in scattered areas near the Green River where the two members could not be differentiated in mapping.

Cretaceous-Jurassic Rocks

KJ Cedar Mountain/Burro Canyon and Morrison Formations, undivided (shown on cross sections only).

Jurassic Rocks

Jmb Brushy Basin Member of Morrison Formation -- Variegated (purple, green, white, orange) mudstone interbedded with gray, white, or brown conglomeratic sandstone, conglomerate, nodular limestone, and gritstone; slope forming with subtle ledges; purple and lavender hues dominate in most areas, but bright green dominates in Cache Valley and in the southeast part of Salt Valley anticline; layers of bentonitic claystone are common, outcrops are generally prone to slumping; contact placed at the base of the mudstone sequence or at the base of the lowest conglomerate ledge; 90 to 135 meters (295-450 ft) thick; Upper Jurassic.

Jms Salt Wash Member of Morrison Formation -- Light-yellow-gray sandstone interbedded with red and gray mudstone and siltstone; sandstone is fine to coarse grained, cross-bedded, and forms medium to thick lenses; mudstone and siltstone form slopes or recesses between sandstone ledges; lower contact at base of first thick sandstone bed above the red and lavender siltstone of the Tidwell Member of the Morrison Formation; locally intertongues with Tidwell siltstones; 40 to 90 meters (130-300 ft) thick; Upper Jurassic.

Jsmt **Jmt** Tidwell Member of Morrison Formation and Summerville Formation, undivided -- Divisible in field, but too thin to map separately at the 1:100,000 scale; Tidwell Member (Jmt) consists of calcareous, thin-bedded lavender, maroon, and light-gray siltstone, light-gray, thin- to thick-bedded, very fine-grained sandstone, and gray thin-bedded or nodular limestone; all slope forming; limestone locally contains large white chert concretions; west of 110° W., locally intertongues with thick white gypsum bodies; 6 to 20 meters (20-65 ft) thick. Summerville unconformably (*J-5* unconformity) overlain by Tidwell Member. In areas where combined with the Tidwell, the Summerville is gray, tan, brown, and red, mostly fine-grained, thin-bedded sandstone and siltstone that forms a steep slope and becomes ledgy near the top; 2-21 meters (6-69 ft) thick. Upper and Middle Jurassic.

Jsm Summerville and Morrison Formations, undivided -- Mapped in areas where Morrison Formation members and the Summerville Formation can't be separated; Upper and Middle Jurassic.

Js Summerville Formation -- Mapped separately near the Green River where it is mostly red sandstone and siltstone; laminated to medium bedded; mostly forms steep slope with light-brown sandstone ledge at top; gypsum nodules and thin beds of gypsum in the upper part in T. 22 and 23 S., R. 16 and 17 E.; lower contact gradational with Curtis Formation in far west; lower contact abrupt at base of a reworked zone of the Moab Tongue of the Curtis Formation overlain by red beds; 2 to 67 meters (6-220 ft) thick (see figure 3, plate 3 for thickness detail); Middle Jurassic.

Jsc Summerville and Curtis Formations, undivided -- Mostly red fine-grained sandstone and siltstone; laminated to medium bedded; commonly forms steep slope; only mapped in T. 23 S., R. 17 1/2 E. and the southwest corner of T. 23 S., R. 18 E.; 30 to 40 meters (100-130 ft) thick; Middle Jurassic.

Jct Curtis Formation -- Brown, gray, green, lavender, and orange fine-grained sandstone and siltstone; mostly thin bedded, argillaceous and calcareous, forms slopes and ledges; contains red, black, and olive-brown chert near top; unconformable lower contact (J-3 unconformity of Pipiringos and O'Sullivan, 1978) with the earthy member of the Entrada Sandstone or the Slick Rock Member of the Entrada Sandstone; 0 to 54 meters (0-177 ft) thick, thickening westward; Middle Jurassic.

Jctm Moab Member of Curtis Formation (member of Entrada Sandstone on previous maps) -- Light-yellow-gray, fine- to medium-grained, cross-bedded, massive, and cliff-forming sandstone; forms a tongue between the Summerville and Entrada Formations and pinches out in the western part of the quadrangle; rests directly on the Slick Rock Member in the east; the lower contact with the Slick Rock Member of the Entrada Sandstone is placed at the base of a prominent parting or a subtle line, probably the J-3 unconformity of Pipiringos and O'Sullivan (1978), which has considerable relief in the Dewey area; 0 to 42 meters (0-138 ft) thick (including the main Curtis where both are present); Middle Jurassic.

Jcec Moab Member of Curtis Formation, Slick Rock Member of Entrada Sandstone, and Dewey Bridge Member of Carmel Formation, undivided-- in areas where they cannot be differentiated.

Ject Entrada and Curtis Formations, undivided -- Mapped in areas where the Slick Rock Member of the Entrada Sandstone and the Moab Member of the Curtis Formation were not differentiated in mapping.

Jee Earthy member of Entrada Sandstone -- Earthy red-brown, fine-grained sandstone; thick nodular to indistinct bedding; more resistant than the Curtis Formation above, but less resistant than the Slick Rock Member of the Entrada Sandstone below; lower contact is generally abrupt, placed above the massive, smooth-weathering sandstone of the Slick Rock; present in R. 16 and 17 E.; the outcrop pinches out in section 11, T. 23 S., R. 17 E.; 0 to 18 meters (0-60 ft) thick; Middle Jurassic.

Jes Slick Rock Member of Entrada Sandstone -- Mostly orange-red or banded orange-red and white sandstone; generally fine grained, eolian cross-bedded; massive with local discontinuous partings; resistant and smooth weathering, but not as resistant as the Moab Member of the Entrada Sandstone; locally pocked with abundant small spherical holes (with diameters up to 10 centimeters) in outcrop; the lower contact is commonly crenulated or contorted above the darker red-brown sandstone of the Dewey Bridge Member of the Carmel Formation; 43 to 152 meters (140-500 ft) thick, thinning eastward; Middle Jurassic.

Jese Earthy and Slick Rock Members of Entrada Sandstone, undivided -- North of Tenmile graben and in scattered areas near the Green River where the two members could not be differentiated in mapping.

Jec Entrada and Carmel Formations, undivided -- Mapped in areas where the Carmel and Entrada Formations were not differentiated in mapping.

Jcd Dewey Bridge Member of Carmel Formation (member of Entrada Sandstone on previous maps) -- Upper half is dark-red, muddy, earthy, fine-grained sandstone; lower half is interbedded dark-red, red-brown, light-brown, and yellow-gray, fine- to medium-grained sandstone; upper half commonly has contorted, nodular, or indistinct bedding and locally contains white beds; upper half forms slopes or recesses between the overlying Slick Rock Member of the Entrada Sandstone and the lower half; lower half is more resistant, is commonly calcareous and cherty, and forms scabs on the underlying Navajo Sandstone; yellow-gray beds in the lower half resemble the underlying Navajo Sandstone, but are flat bedded; lower half is locally missing, especially in the east; lower contact is the *J-2* unconformity of Pipiringos and O'Sullivan (1978); 8 to 72 meters (25-235 ft) thick, generally thinning eastward; Middle Jurassic.

Jcu Upper Carmel Formation -- Western correlative of the upper half of the Dewey Bridge Member; mostly medium- to red-brown, fine-grained sandstone, with interbedded ledges of light-yellow sandstone and subordinate conglomerate and finely laminated, chippy-weathering calcareous siltstone; red-brown sandstones display indistinct bedding identical with that in the upper half of the Dewey Bridge Member; mapped as the upper Carmel Formation where chippy-weathering calcareous siltstones appear; lower contact is at the top of a distinctive white-weathering calcareous siltstone in the lower Carmel Formation; 30 to 37 meters (100-120 ft) thick; Middle Jurassic.

Jcl Lower Carmel Formation -- Western correlative of the lower half of the Dewey Bridge Member; light-gray, light-brown, mostly fine-grained sandstone, in medium to thick, flat beds; generally capped by white to lavender, chippy-weathering, finely laminated calcareous siltstone; mapped where white to lavender siltstone appears; lower contact placed above upturned edges of Navajo Sandstone cross-beds (*J-2* unconformity of Pipiringos and O'Sullivan, 1978); 24 to 27 meters (80-90 ft) thick; Middle Jurassic.

Jsr San Rafael Group, undivided (shown on cross sections only) -- Includes Summerville and Curtis Formations, all members of the Entrada Sandstone, and upper and lower members of the Carmel Formation.

Jn **Jnl** Navajo Sandstone -- Mostly light-hued, fine- to medium-grained, eolian cross-bedded, massive sandstone; lower third commonly weathers to a cliff, the remainder into domes and rounded knolls; locally contains thin, hard, gray limestone beds (Jnl); lower contact placed at the top of a thick, white to pink sandstone in the Kayenta Formation; 0 to 225 meters (0-740 ft) thick, pinches out to the northeast over the Uncompahgre uplift; Lower Jurassic.

Jk Kayenta Formation -- Red-brown, lavender-gray, fine- to coarse-grained, medium- to thick-bedded sandstone; contains local white and dark-brown beds, intraformational conglomerate, and limestone; forms thick ledges; generally contains abundant red slope-forming siltstone in upper third; lower contact is a scoured surface in the massive orange-brown Wingate Sandstone; 30 to 90 meters (100-300 ft) thick; Lower Jurassic.

Jw Wingate Sandstone -- Orange-brown, dark-brown-weathering, fine-grained, massive sandstone; forms vertical cliff along canyon walls, commonly stained by desert varnish; abrupt contact with underlying Chinle Formation placed at base of massive, cliff-forming sandstone or on top of thick, orange-brown, flat-bedded sandstone (*J-0* unconformity) below which typical Chinle slope-forming siltstones and sandstones are found; 75 to 137 meters (250-450 ft) thick; Lower Jurassic.

Jgc Glen Canyon Group -- Navajo, Kayenta, and Wingate Formations, where exposures cannot be differentiated; combined Navajo, Kayenta, and Wingate Formations also shown on cross sections.

Triassic Rocks

Trc Chinle Formation -- Red-brown sandstone, siltstone, conglomeratic sandstone, and mudstone; forms steep slope with Moenkopi Formation below; has basal member of quartzose gritstone or sandstone and mottled siltstone and sandstone beneath an unconformity; contains multiple intraformational unconformities adjacent to salt diapirs; lower contact is the *Tr-3* unconformity of Pipiringos and O'Sullivan (1978), which is slightly angular; 0 to 275 meters (0-900 ft) or more thick, greatest thickness in rim synclines adjacent to salt-cored anticlines and locally missing on anticlines; only 12 to 30 meters (40-100 ft) over Precambrian rocks on the Uncompahgre uplift to the northeast; Upper Triassic.

Trm Moenkopi Formation -- Red-orange, chocolate-brown, and medium-brown sandstone, silty sandstone, and minor siltstone and conglomerate; generally divisible into two to four members, but are undivided on the map; lower contact is the *Tr-1* unconformity of Pipiringos and O'Sullivan (1978), which is slightly angular and is found at the top of the more red-brown sandstone of the underlying Cutler Formation; total thickness is 0 to 400 meters (0-1,300 ft) or more, thinning regionally eastward and may be missing on the Uncompahgre uplift in the northeast and very thick in rim synclines adjacent to salt-cored anticlines; Middle (?) to Lower Triassic.

Tr Triassic formations (shown on cross sections only) -- Chinle and Moenkopi Formations, undivided.

Permian Rocks

Pc Cutler Formation -- Interbedded red-brown subarkosic, arkosic, and micaceous sandstone and lavender-brown conglomerate; sandstone is fine to coarse grained and gritty in eastern exposures; low- to high-angle cross-beds, thin bedded to massive, and forms smooth and rounded ledges; conglomerate is mostly pebbles to 13-centimeter (5-inch) cobbles, but cobbles exceeding 30 centimeters (1 ft) or more in diameter are common in the eastern part of the quadrangle; chert, quartzite, granite, felsite, gneiss, and schist clasts; matrix is poorly sorted, fine- to coarse-grained sandstone; grains of quartz, lithic fragments, mica, feldspar, and unidentified black minerals; laminated to indistinct bedding; weathers to smooth irregular slopes or gentle ledges; lower contact is placed above a gray limestone ledge that contains Late Pennsylvanian (Virgilian) fusulinids; 0 to 2,450 meters (0-8,000 ft) thick; missing over some salt-cored anticlines, thickest at the west edge of the Uncompahgre uplift; as much as 1,000 meters (3,300 ft) exposed; 75 meters (245 ft) of gray-white, cross-bedded quartzose sandstone at the top of the Cutler Formation in the north part of the southwest flank of Castle Valley may be an outcrop of White Rim Sandstone; Lower Permian.

P Permian formations (shown on cross sections only) -- Cutler Formation and up to 18 meters (60 ft) of Kaibab Formation and 130 meters (430 ft) of White Rim Sandstone that overlie the Cutler Formation in subsurface in the west part of the quadrangle; both pinch out to the east.

Pennsylvanian Rocks

IPh Honaker Trail Formation and Paradox Formation undifferentiated (mapped only in Salt Valley).

IPh Honaker Trail Formation -- Interbedded sandstone, siltstone, limestone, and subarkosic sandstone; limestone is commonly fossiliferous; the lower contact is not exposed, but the unit is juxtaposed against Paradox Formation and O'Sullivan (1978), which is slightly angular and is found at the top of the more red-brown sandstone of the underlying Cutler Formation; total thickness is 0 to 400 meters (0-1,300 ft) or more, thinning regionally eastward and may be missing on the Uncompahgre uplift in the northeast and very thick in rim synclines adjacent to salt-cored anticlines; Middle (?) to Lower Triassic.

IPpc Paradox Formation caprock -- Mostly light-gray, contorted gypsum with interlayered black and gray shale, thin chippy limestone, and sandstone; locally exposed in salt valleys and along salt-dissolution deformed bedrock; caprock is the residue after salt is dissolved from the Paradox Formation; up to 200 meters (650 ft) exposed and may reach a total of 350 meters (1,150 ft) in the subsurface.

IPp Paradox Formation (shown on cross sections only) -- Interbedded evaporite, clastic, and carbonate rocks; evaporites include finely laminated halite, sylvite, carnallite, and anhydrite and may constitute as much as 85 percent of the formation; clastic and carbonate rocks are interbedded shale, siltstone, limestone, and dolomite and are grouped into "marker beds" (Hite, 1977); includes Pinkerton Trail and Molas Formations (see lithologic column); 0 to 1,370 meters (0-4,500 ft) thick in Paradox basin, but as much as 4,300 meters (14,100 ft) thick in salt-cored anticlines, salt commonly missing adjacent to salt-cored anticlines, formation missing on Uncompahgre uplift; Middle Pennsylvanian.

Xd Granodiorite and quartz diorite gneiss -- Quartz-plagioclase, with or without K-feldspar, gneiss with about 10 to 20 percent hornblende plus biotite; medium to coarse grained with weak to strong foliation; larger bodies form black to dark-gray boulderly outcrops; also occurs as smaller unmapped dikes in the biotite gneiss; Lower Proterozoic.

Xg Biotite gneiss, gneiss, and schist -- Contain varying proportions of quartz, plagioclase, and K-feldspar, with about 10 to 30 percent biotite and minor muscovite, hornblende, garnet, and rare sillimanite; generally fine grained, well foliated, thinly layered, and openly to isoclinally folded; locally migmatitic with medium-grained granitic dikelets and segregations, and locally intruded by variably deformed dikes of granodiorite and quartz diorite gneiss; forms dark-gray to black, boulderly outcrops; Lower Proterozoic.

Xb Amphibole gneiss -- Hornblende-plagioclase gneiss with minor quartz, biotite, and K-feldspar; locally interlayered with thin bands of metaquartzite; fine to medium grained and generally strongly foliated and lineated; gneiss forms small, non-resistant black outcrops with local quartzite ledges; Lower Proterozoic.

Xa Felsic gneiss -- Quartz-K-feldspar-plagioclase gneiss with about 5 to 15 percent biotite; overall granitic composition, but locally variable; medium grained with strong foliation and lineation defined by preferred orientation of biotite; gneiss forms pink-gray to purple-red outcrops locally cut by dikes of pegmatite, aplite, and quartz; Lower Proterozoic.

Xf Aplite and pegmatite -- Aplite - Overall fine-grained, non-foliated granitic rock with varying amounts of quartz, K-feldspar, and plagioclase; forms pink to red fractured outcrops locally cut by quartz veins and pegmatite dikes. Pegmatite - Shown near Coates Creek; medium- to coarse-grained, pink to white rock with varying amounts of quartz, K-feldspar, plagioclase, biotite, and muscovite. Both Middle Proterozoic.

Yg Granite -- Coarse-grained, porphyritic, generally non-foliated rock containing subequal amounts of quartz, K-feldspar, and plagioclase, with minor hornblende, biotite, and opaque minerals; mostly granite in composition, but includes some quartz monzonite and granodiorite; contains large pink K-feldspar crystals generally up to 8 centimeters (3 inches) in diameter; forms gray to pink-gray bouldery outcrops cut by pegmatite, aplite, and quartz dikes and veins; Middle Proterozoic.

Ybg Biotite granodiorite -- Gray to pink, fine- to medium-grained; composed of various amounts of plagioclase, K-feldspar, quartz, and biotite; age relative to granite (Yg) uncertain; Middle Proterozoic.

pC Precambrian rocks (shown on cross sections only) -- Basement rocks.

Precambrian Rocks

Yq Quartz pegmatite -- Mostly fine- to coarse-grained quartz with feldspar; Middle Proterozoic.

Yl Lamprophyre -- Composed of amphibole, biotite, feldspar, and quartz; exposed as dikes, sills, or plugs in Lower Proterozoic rocks so age relative to other Middle Proterozoic rocks is uncertain; Middle Proterozoic.

Yap Aplite and pegmatite -- Aplite - Overall fine-grained, non-foliated granitic rock with varying amounts of quartz, K-feldspar, and plagioclase; forms pink to red fractured outcrops locally cut by quartz veins and pegmatite dikes. Pegmatite - Shown near Coates Creek; medium- to coarse-grained, pink to white rock with varying amounts of quartz, K-feldspar, plagioclase, biotite, and muscovite. Both Middle Proterozoic.

GEOLOGIC SYMBOLS

CONTACT -- Includes contacts approximately located or inferred

FAULT -- Dashed where approximately located; dotted where concealed. Bar and ball on down-thrown block

ANTICLINE -- Arrow shows plunge direction

SYNCLINE -- Arrow shows plunge direction

MONOCLINE -- Arrow shows plunge direction; T24S, R22E

2000 STRUCTURAL CONTOUR-drawn on top of Chinle Fm. (most of map) and on top of Cedar Mtn. Fm. (north area); contour interval 100 meters

5 Strike and dip of strata

Mobil #1-30 Drill hole listed in table 1

Fault on cross section with arrow showing sense of relative movement

Cross Section — Geologic Map

Qf Qal Qaf Qam Qag Qes Qed Qmt Qms Qcb Qgt Qst Qea Qab QTaf Qat Qap

Tg Ti

Kf Kn Ks Kmb Kc Kb Kmu Kms Kmv Km Kmf Kd Kdcm Kdbc Kbc

KJ

Jmb Jms Jmt Jsmt Jsm Js Jcu Jcl Jcd Jcec Jec Jsc Jctm Jct Jes Jese Jee

Jgc Jk Jn Jnl Jw

Tr Trc Trm

P IPh IPpc IPp MI DC

pC Yq Yap Yg Yl Ybg Xd Xg Xb Xa Xf

CORRELATION OF GEOLOGIC UNITS (see description on plate 2)

Quaternary — Holocene — Pleistocene — unconformity — Pliocene — Tertiary — Oligocene — unconformity

Cretaceous — Upper Cretaceous — West — East — unconformity — Lower Cretaceous — West — unconformity

Jurassic — Upper Jurassic — West — *J-5 unconformity* — East — West — *J-4 unconformity* — Middle Jurassic — West — East — *J-3 unconformity* — Lower Jurassic — West — East — *J-0 unconformity?*

Triassic — Upper Triassic — Lower Triassic — *Tr-3 unconformity* — *Tr-1 unconformity*

Permian — Lower Permian — Upper Pennsylvanian — Middle Pennsylvanian — unconformity — Mississippian — unconformity? — Devonian and Cambrian — unconformity

Proterozoic — Middle Proterozoic — Lower Proterozoic

Age relative to other Y units not known

Age relative to Yg uncertain

FIGURE 1. Principal structural features of the map area. Form contours (dashed) have a 200-meter interval. Datum is top of Chinle Formation.

FIGURE 2. Outcrop map of interval between the Slick Rock Member of the Entrada Sandstone and the Salt Wash Member of the Morrison Formation. Circled numbers refer to columns correlated on figure 3.

FIGURE 3. Correlation of interval between the Slick Rock Member of the Entrada Sandstone and the Salt Wash Member of the Morrison Formation across the map area. The approximate location of each measured section or column is shown on figure 2. The section, township, and range are given above each column. Numeric thicknesses are in meters; NM means not measured.